ACETALDEHYDE

Acetaldehyde is a federal hazardous air pollutant and was identified as a toxic air contaminant in April 1993 under AB 2728.

CAS Registry Number: 75-07-0 CH_3CHO

Molecular Formula: C_2H_4O

Acetaldehyde is a colorless, fuming liquid and at dilute concentrations has a fruity, pungent odor. As a liquid, it is lighter than water but the vapors are heavier than air. It is miscible in water, alcohol, acetone, gasoline, toluene, xylene, benzene, ether, paraldehyde and organic solvents. Acetaldehyde is volatile at ambient temperature and pressure. Both the liquid and the vapors are highly flammable and acetaldehyde is a dangerous fire hazard when exposed to heat or flames (Sax, 1989). It is highly reactive and a strong reducing agent which undergoes numerous condensation, addition and polymerization reactions. Acetaldehyde can react violently with acid anhydrides, alcohols, ketones, phenols, ammonia, hydrogen cyanide, hydrogen sulfide, halogens, phosphorus, isocyanates, strong alkalis, and amines (Sax, 1989).

Physical Properties of Acetaldehyde

Synonyms: ethanal; acetic aldehyde; ethyl aldehyde; methyl formaldehyde

Molecular Weight:	44.06
Boiling Point:	20.8 °C
Melting Point:	-123.5 °C
Flash Point:	-38.0 °C
Vapor Density:	1.52 (air = 1)
Vapor Pressure:	740 mm Hg at 20 °C
Density/Specific Gravity:	0.79 at 18/4 °C
Log Octanol/Water Partition Coefficient:	0.43
Conversion Factor:	1 ppm = 1.8 mg/m^3

(HSDB, 1995; Merck, 1989; Sax, 1989; U.S. EPA, 1994a)

SOURCES AND EMISSIONS

A. Sources

Sources of acetaldehyde include emissions from combustion processes such as vehicular exhaust from mobile sources and fuel combustion from stationary internal combustion engines, boilers and process heaters. Combustion of gasoline containing the oxygenate additives ethanol or ethyl tert-butyl ether (ETBE) may also emit acetaldehyde (U.S. EPA, 1993b). Acetaldehyde is also a product of incomplete combustion in fireplaces and woodstoves, coffee roasting, burning of tobacco, and waste processing. Acetaldehyde is used as an intermediate in the production of acetic acid, acetic anhydride, ethyl acetate, peracetic acid, pentaerythritol, chloral, glyoxal, alkylamines and pyridines (ARB, 1993c). Acetaldehyde is also used as a fruit and fish preservative, flavoring agent, a denaturant for alcohol, for hardening gelatin fibers, and as a solvent in the synthetic rubber, paraldehyde, tanning and paper industries (Sittig, 1985; U.S. EPA, 1987a). It is also used in the manufacture of perfumes, butanol, aniline dyes, plastics, and silvering mirrors (Merck, 1989).

In California, photochemical oxidation is the largest source (as high as 41 to 67 percent) of acetaldehyde concentrations in the ambient air. Also in California, burning of wood in residential fireplaces and woodstoves, wildfires, and agricultural burning are sources of emissions, followed by various stationary sources such as oil and gas extraction, refineries, cement kilns, and lumber and wood products (ARB, 1993c). The primary stationary sources that have reported emissions of acetaldehyde in California are paper mills, crude oil and natural gas mining, and petroleum refining (ARB, 1997b).

B. Emissions

The total emissions of acetaldehyde from stationary sources in California are estimated to be at least 190,000 pounds per year, based on data reported under the Air Toxics “Hot Spots” Program (AB 2588) (ARB, 1997b). In 1994, the Air Resources Board (ARB) also estimated that approximately 4 million pounds per year were emitted from on-road motor vehicles (ARB, 1995f). ARB also estimates that emissions from other mobile sources such as off-road recreational vehicles, boats, ships, and trains contribute an additional 1.6 million pounds per year of acetaldehyde into California's air (ARB, 1995f).

C. Natural Occurrence

Acetaldehyde occurs in nature as an intermediate product in the respiration of higher plants and can be found in ripening fruit such as apples. Also, acetaldehyde is an intermediate product of fermentation of alcohol and in metabolism of sugars in the body (ARB, 1993c).

AMBIENT CONCENTRATIONS

Acetaldehyde is routinely monitored by the statewide ARB air toxics network. When acetaldehyde was formally identified as a toxic air contaminant, the ARB estimated a population-weighted annual concentration of 4.19 micrograms per cubic meter ($\mu g/m^3$) or 2.33 parts per billion (ppb) (ARB, 1993c). The network's mean concentration of acetaldehyde from January 1996 through December 1996 is estimated to be 2.39 $\mu g/m^3$ or 1.33 ppb (ARB, 1997c).

Ambient air sampling of two rural regions, Point Barrow, Alaska and Whiteface Mountain, New York indicate "background" acetaldehyde concentrations are from the 0 to 1.4 $\mu g/m^3$ (0 to 0.8 ppb) (ARB, 1993c). The United States Environmental Protection Agency (U.S. EPA) also reported concentrations of acetaldehyde from 14 study areas during 1989. The overall acetaldehyde mean concentrations in these areas was of 2.5 $\mu g/m^3$ (1.39 ppb) (U.S. EPA, 1993a).

INDOOR SOURCES AND CONCENTRATIONS

In general, concentrations are higher indoors than outdoors due in part to the abundance of combustion sources such as cigarettes, fireplaces, and woodstoves. Acetaldehyde can be emitted from cooking hamburgers, and from some building materials such as rigid polyurethane foams, and some consumer products such as adhesives, coatings, lubricants, inks, and nail polish remover. Other potential sources of indoor acetaldehyde concentrations are the infiltration of vehicle exhaust and the volatilization of acetaldehyde from certain foods (ARB, 1993c).

Residences with smokers have two to eight times higher acetaldehyde concentrations than the outdoor mean population-weighted statewide concentration of 4.19 $\mu g/m^3$ (2.3 ppb). Limited surveys allow a crude estimate of an average acetaldehyde concentration inside residences of 5.4 to 27.0 $\mu g/m^3$ (3.0 to 15 ppb). Limited data suggest that the acetaldehyde concentrations in offices and public buildings are similar in magnitude to those inside residences. Higher levels may occur in some indoor environments; in the case of a tavern occupied by a number of smokers, levels of up to 203.4 $\mu g/m^3$ (113 ppb) were reported. Average and maximum in-vehicle acetaldehyde concentrations measured in southern California were similar in magnitude to those inside residences (ARB, 1993c).

ATMOSPHERIC PERSISTENCE

Acetaldehyde exists in the atmosphere in the gas phase. It also can be formed in the atmosphere as a result of photochemical oxidation of organic pollutants in urban atmospheres (ARB, 1993c). The dominant atmospheric loss process for acetaldehyde is by reaction with the hydroxyl radical. Based on this reaction, the atmospheric half-life and lifetime is estimated

to be 15 hours and 22 hours, respectively (Atkinson, 1994). The products of this reaction include formaldehyde and peroxyacetyl nitrate (PAN) (Atkinson, 1995).

AB 2588 RISK ASSESSMENT INFORMATION

The Office of Environmental Health Hazard Assessment reviews risk assessments submitted under the Air Toxics "Hot Spots" Program (AB 2588). Of the risk assessments reviewed as of April 1996, acetaldehyde was the major contributor to the overall cancer risk in 1 of the approximately 550 risk assessments reporting a total cancer risk equal to or greater than 1 in 1 million and contributed to the total cancer risk in 129 of the these risk assessments. Acetaldehyde also contributed to the total cancer risk in 31 of the approximately 130 risk assessments reporting a total cancer risk equal to or greater than 10 in 1 million (OEHHA, 1996a).

For non-cancer health effects, acetaldehyde contributed to the total hazard index in 19 of the approximately 89 risk assessments reporting a total chronic hazard index greater than 1. Acetaldehyde also contributed to the total hazard index in 3 of the approximately 107 risk assessments reporting a total acute hazard index greater than 1 (OEHHA, 1996b).

HEALTH EFFECTS

Human exposure to acetaldehyde occurs primarily through inhalation (Howard, 1990).

Non-Cancer: Acute exposure to acetaldehyde vapor leads to eye, skin and respiratory tract irritation. Prolonged exposure of the skin to liquid acetaldehyde causes erythema and burns; repeated contact may lead to dermatitis due to primary irritation or sensitization. Long-term or chronic exposure has been shown to damage the respiratory tract in rats. In hamsters, chronic exposure to acetaldehyde has produced changes in the nasal mucosa and trachea, growth retardation, slight anemia, and increased kidney weight (U.S. EPA, 1994a).

A chronic non-cancer Reference Exposure Level (REL) of 9.0 $\mu g/m^3$ is listed for acetaldehyde in the California Air Pollution Control Officers Association Air Toxics "Hot Spots" Program, Revised 1992 Risk Assessment Guidelines. The toxicological endpoint considered for chronic toxicity is the respiratory system (CAPCOA, 1993). The U.S. EPA has established a Reference Concentration (RfC) of 9.0 $\mu g/m^3$ based on degeneration of olfactory epithelium in rats, and has not determined a Reference Dose (RfD) (U.S. EPA, 1994a).

No information is available regarding adverse reproductive or developmental effects of acetaldehyde in humans (U.S. EPA, 1994a). In animal studies, acetaldehyde has been shown to cross the placenta. Resorptions, malformation, reduced birth weight and increased postnatal mortality have been reported in rodents given acetaldehyde by injection (U.S. EPA, 1994a).

Cancer: Human data for carcinogenic effects of acetaldehyde are inadequate. An increased incidence of nasal tumors in rats and laryngeal tumors in hamsters has been observed following

inhalation exposure to acetaldehyde. The U.S. EPA classified acetaldehyde in Group B2: Probable human carcinogen on the basis of sufficient evidence for carcinogenicity in animals and inadequate evidence in humans, and determined an inhalation potency value of 2.2×10^{-6} (microgram per cubic meter)$^{-1}$. The U.S. EPA estimates that if an individual were to breathe air containing acetaldehyde at 0.5 $\mu g/m^{3,}$ over a lifetime, that person would theoretically have no more than a 1 in 1 million increased chance of developing cancer (U.S. EPA, 1994a). The International Agency for Research on Cancer classified acetaldehyde in Group 2B: Possible human carcinogen based on sufficient evidence in animals and inadequate evidence in humans (IARC, 1987a).

The State of California has determined under Proposition 65 that acetaldehyde is a carcinogen (CCR, 1996). The inhalation potency factor that has been used as a basis for regulatory action in California is 2.7×10^{-6} (microgram per cubic meter)$^{-1}$ (OEHHA, 1994).
In other words, the potential excess cancer risk for a person exposed over a lifetime to 1 $\mu g/m^3$ of acetaldehyde is estimated to be no greater than 3 in 1 million (OEHHA, 1994).